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Montana's Post and Pole Industry—An Economic Analysis of Production and Markets

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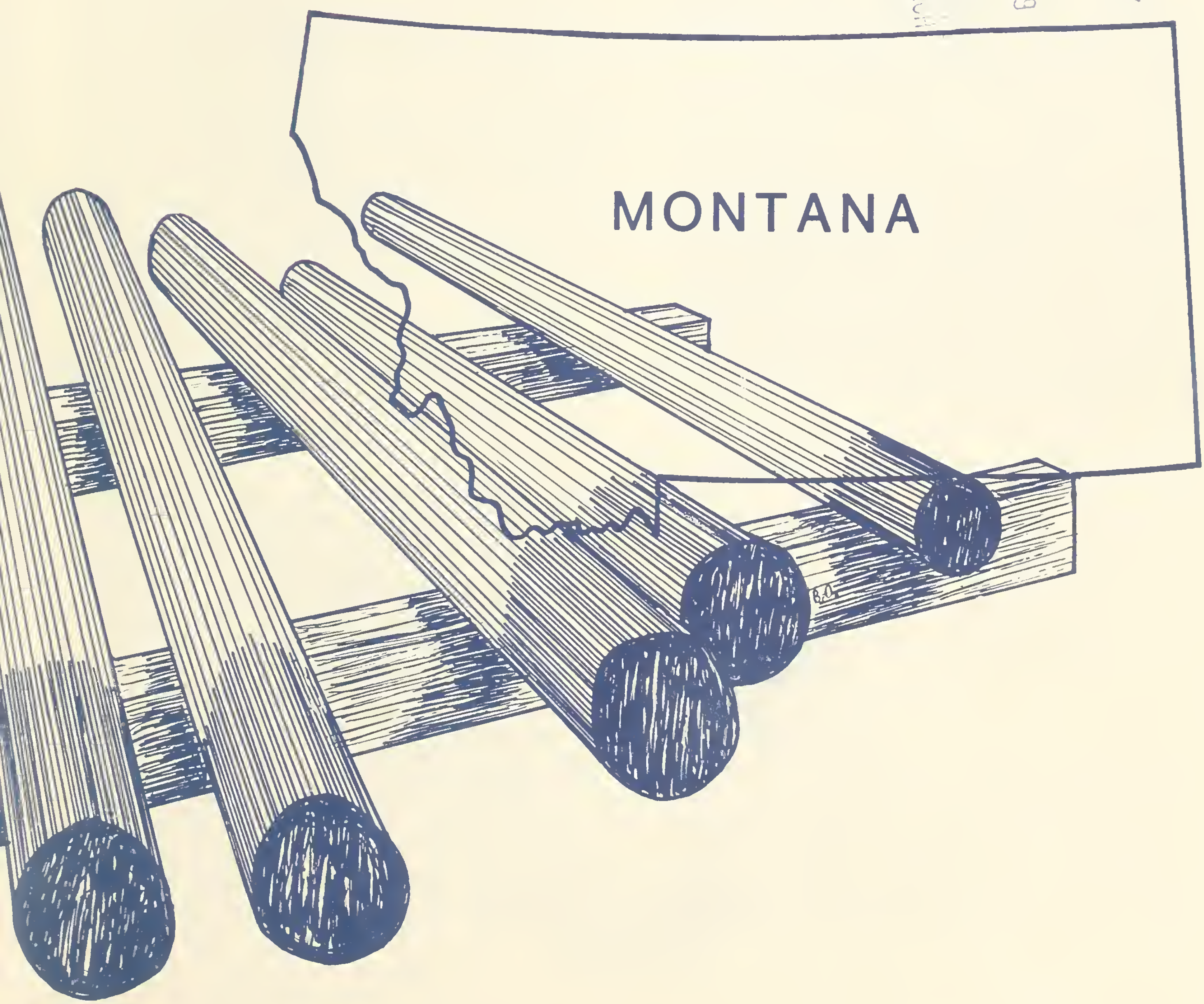

THE AUTHORS

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RESEARCH SUMMARY

Several important dimensions of the Montana post and pole manufacturing industry are presented. While startup costs are reasonably low, the production of products is highly concentrated among a few firms. A key to firm size appears to be the company's apparent success in finding and exploiting out-of-state markets. By comparision with other firms in the solid wood products manufacturing industry, even the large post and pole producers are comparatively small. Only three firms reported that the replacement cost of their capital equipment exceeds $500,000. Because fence posts are the most important product produced, it is not surprising that the economic health of agribusiness is cited as the most important factor affecting demand for post and pole products.

Several regression equations were used to summarize raw material and finished product prices. These can be used to indicate how raw material and product sizes along with other qualitative characteristics influence prices. In addition to statistical models regarding product values, the study concludes that raw material supply and demand are both highly price elastic. Hence quantities purchased and sold are very sensitive to small price changes. These conclusions are based on a variety of models including a model estimating the relationship between capital and labor employed in manufacturing post and pole products as well as a willingness-to-pay questionnaire response.

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INTRODUCTION

An economic history of Montana's wood-using industry would show two distinct trends in the supply of raw materials. Over time, an increasing number of native tree species have become commercially significant. Second, corresponding to the expansion of the species utilized, there has been a decrease in the size of trees logged.

In the 1930's, the two species of greatest commercial importance were western white pine (*Pinus monticola*) and ponderosa pine (*Pinus ponderosa*). During that same time, published reports indicate that timber had to be greater than 24 inches in diameter at breast height (d.b.h.) in order to be logged profitably (Baker 1950). Although no parallel estimate of the marginal tree exists for current markets, unpublished data about timber logged in the Northern Rockies are indicative. Figures available from the Northern Region of the Forest Service, U.S. Department of Agriculture, show that the average tree logged on land under its jurisdiction in western Montana and northern Idaho was 17 inches d.b.h. in 1970. By 1984 the average tree size was less than 12 inches d.b.h. for the same geographic area.

Currently, 41 percent of all softwood trees greater than 1 inch d.b.h. on commercial forest land in Montana is lodgepole pine (*Pinus contorta*) and 30 percent is lodgepole 5 inches d.b.h. or less (Green and others 1986). Many land management problems stem from a lack of options for dense, growth-stagnant stands of small-diameter lodgepole pine.

Clearly, the days of a wood products economy based on large-diameter logs are gone. The profitable manufacture of wood products today must entail the use of exceedingly small-diameter timber in order to keep raw materials costs low. In Montana, lodgepole pine is the prevalent small-diameter species available for utilization.

As Benson (1984) indicates, small-diameter lodgepole pine is already being processed in Montana and in the Intermountain West. Lumber and plywood manufacturers are moving toward the use of small logs, while post and pole processors utilize the smallest timber. Stands consisting of 5- to 7-inch d.b.h. size classes are the main candidates for post and pole use. The demand for this kind of raw material is in turn derived primarily from the demand for post and pole products.

Considerable time and effort have been spent studying the lumber, plywood, and pulp and paper sectors. Aside from a basic census of Montana's wood manufacturers (Keegan 1980), there is virtually no information available about post and pole production. The purposes of this study are to compile, describe, and analyze information about the post and pole sector in Montana. Although the primary impetus for this study arose from land management concerns, the findings are pertinent to the performance of Montana's economy. A better understanding of current small-diameter post and pole operations and product markets could be the basis for expanded production. An improved product market would in turn lead to an improved log market and expanded options for using "problem" lodgepole pine stands.

STUDY DESCRIPTION

Objectives

The growing importance of small-diameter lodgepole pine as a source of raw materials warrants an investigation into a sector of the wood products industry that utilizes small logs. In Montana, the principal and virtually exclusive purchasers of small-diameter logs (under 6 inches in diameter) are post and pole producers.

The specific objectives of this study are as follows:

1. Describe the products and level of production for the sector.
2. Characterize the firms comprising the sector.
3. Describe the product markets and distribution channels.
4. Identify the sources of supply for raw materials.
5. Relate the size of the firms to markets and raw materials.
6. Analyze raw material and finished product.
7. Estimate sector demand for raw materials.
8. Determine the costs of production.

Data Collection

The nature of this study and the lack of available information from secondary sources mandated that data should be collected directly from post and pole manufacturers. A list of all known post and pole producers in Montana in 1985 was obtained from the Montana Division of Forestry, Department of State Lands. This list was the basis for establishing the study population.

Attempts were made to contact each of the 43 post and pole operations identified. Of the original list, 17 could not be contacted after repeated attempts or were no longer in business. Two did not produce small-diameter roundwood products. Of the remaining 24, 23 responded positively to a request for information in the form of a telephone survey, while one business declined to provide complete information. Price lists for products and raw materials were obtained from 13 post and pole producers.

The profile of the post and pole industry presented in this study is based on a census of all known producers in the State rather than on a sample. Of the pool of 24 known producers, only three were excluded from the final analysis. Two of this pool provided only partial information. One producer, the Montana State Prison, was considered to be unrepresentative of the larger industry because of the noncompetitive nature of its wage rates and its restricted product market (State agencies). Another producer owned post and pole operations in two locations and combined their production data. Thus, this study represents an 88 percent census of known post and pole producers in spring 1985.

Problems in Measurement

A wide variety of post and pole products are manufactured in Montana, which results in a broad range of product prices. Products are not only diverse but lack uniformity in size. This complicated the measurement of production activities.

Manufacturers reported production in terms of the number of pieces produced. There are no published volume tables available for small roundwood lodgepole pine logs by piece. As the study progressed, it became increasingly apparent that the reporting and analysis of production data would be facilitated by converting to cubic-foot volume estimates. Volume estimates are more familiar to people outside the post and pole business and are more comparable to production data in other sectors of the larger wood-processing industry.

Cubic-foot estimates of the small-diameter products entailed the application of a taper factor of $^5/_8$ inch per 8-foot length of raw material to the piece data supplied by post and pole producers. In addition to the number of pieces, average small-end diameter and length data were obtained. The taper factor or value was used to predict large-end diameter, and then cubic-foot volume estimates were calculated based on length and average diameter. No allowances were made for peeling, drilling, capping, or pointing of materials.

The diversity of product sizes is no doubt related to the shape and form of the trees utilized in manufacturing post and pole products. Although the lack of cubic volume estimates is a problem from a research perspective, it is of little importance to producers and buyers. For instance, purchasers of fenceposts most likely buy posts of a certain diameter and length rather than on the basis of cubic volume. The number of pieces of a particular size is far more important than the volume of wood.

INDUSTRY DESCRIPTION

Products Manufactured

Firms classified as part of the post and pole processing sector manufacture a variety of roundwood products. Fenceposts not only vary in diameter and length, but in treatment with preservative, that is fully, partially, or butt-treated or untreated. In addition, fenceposts may be peeled or unpeeled, pointed or unpointed. Posts produced for decorative purposes are drilled for rails; the number of holes depends on the number of fence rails to be supported. Jackleg fenceposts are manufactured so that pairs stand above ground in a crossed position. These fences are most often used where rocky soil conditions preclude the digging of post holes or the driving of fenceposts.

Rails are available in treated or untreated form and may be peeled or unpeeled. Those manufactured for use as decorative fencing have doweled ends to fit holes bored in the post. Gates are available either assembled or unassembled. Haystack panels and portable corrals are manufactured by a few post and pole yards, as are barn poles, tree props, and grape stakes.

In addition to roundwood production, some post and pole firms operate small sawmills. Although data on lumber production were not included in this study, it is of note that this minor degree of integration within the wood products industry has taken place in the post and pole sector.

The prices for the products manufactured by the post and pole industry reflect both the degree of processing and raw material costs. As in the case of production volume, the diversity of product prices necessitated the development of a standardized price measure rather than the use of prices reported directly by manufacturers. Thus, a set of price equations were developed that related price to size and volume as a means of reporting raw material and product prices.

Description of Firms

Montana's post and pole sector is geographically dispersed in 17 counties on both sides of the Continental Divide. Post and pole firms range in size from small, part-time operations employing less than one person on an annual basis to larger scale plants with an average annual employment of 45 people. Overall, the sector is characterized by relatively small employment, with only two firms employing 20 or more employees and 13 employing six or fewer employees. The average annual employment (including full and part time) is seven.

The payrolls of post and pole producers ranged from \$6,000 to \$500,000, with an average payroll of \$90,500. Reflective of the small number of employees, 13 of the producers had payrolls less than \$50,000. A summary of employment and payroll information is provided in table 1.

Table 1—Employment and payroll summary—Montana post and pole sector (one firm unreported)

Employees	Firms	Payroll	Firms
0 - 3	13	$ 6,000 - $10,000	3
4 - 6	5	11,000 - 20,000	2
7 - 10	1	21,000 - 30,000	5
11 - 20	0	31,000 - 50,000	3
20 +	2	51,000 - 199,000	4
		200,000 +	3
Total	21		20

Table 2—Volume estimates of small-diameter roundwood products—Montana post and pole sector

Product	Volume	Total production
	Ft³	*Percent*
Posts	1,709,948	55.6
Poles	359,305	11.7
Utility poles	41,638	1.4
Barn poles	118,860	3.9
Rails	487,022	15.8
Props	255,965	8.3
Decorative fencing	101,049	3.3
Total	3,073,787	100.0

Information about the capital stock of the post and pole sector was obtained from producers who were asked to estimate the replacement value of plant and equipment, including vehicles. The results were:

Estimated value	Number of firms
$ 0 - 20,000	4
21,000 - 60,000	4
61,000 - 100,000	4
101,000 - 250,000	3
251,000 - 500,000	3
501,000 +	3
Total	21

The value of the capital stock for more than half of the industry is less than $100,000.

Levels of production were calculated by converting numbers of pieces for each product into estimates of cubic-foot volume (see Problems in Measurement). The seven major products are shown in table 2.

Posts—the only product manufactured by all firms—accounted for the largest volume of production. Only two firms produced utility poles and barn poles, eight made decorative fencing, 16 manufactured rails, and 17 made other kinds of poles.

The Degree of Competition

Manufacturing may be characterized according to the degree of competition present in the industry. A competitive industry is one in which the level of production of any one firm will exert a negligible influence on the prices of products sold or on the unit costs of raw materials and other factors of production purchased. In contrast, a monopolistic industry represents a form of "price-seeking" behavior. A monopolistic firm is able to govern its production as a means of influencing the price of the products it manufactures and sells. Likewise, firms that can influence the price paid for raw materials and other factors of production are called monopsonists.

Competition and monopoly are extremes and are useful in describing industrial organization. But most manufacturing in the United States is neither purely competitive nor purely monopolistic. The degree of competition represents a more realistic way of classifying an industry or sector. In determining the degree of competition, several factors are usually evaluated. Are there barriers limiting new entrants to the industry such as large capital requirements or legal limitations such as patents or licenses? Are there close substitutes for the products? Are there particular brands that evoke consumer loyalties? Finally, is production dominated by a few firms?

By these criteria, it appears as though post and pole manufacturing in Montana is highly competitive, although not all of the indicators point in this direction. Rapid turnover of firms is indicated by the number of firms no longer in business or that could not be reached by telephone at the time of the survey. In addition, little capital is required to enter the post and pole business. Only three of 21 firms reported the replacement value of their capital stock to be in excess of $500,000, while four estimated the replacement value of their capital stock as less than $6,000.

The presence of substitute products indicates a competitive industry. As shown in table 3, fenceposts are the most important roundwood product of the post and pole sector. Obvious substitutes are metal posts. Barbed wire and woven fence are replacements for wooden rails, and lumber and metal products may be substituted for roundwood panels, gates, and so on. There is little evidence of brand preference for these goods, which suggests that the post and pole sector is competative.

Domination of an industry by a few firms suggests something less than perfect competition. Figure 1 illustrates that the Montana post and pole industry is highly concentrated. The straight line represents a theoretical distribution of production if all firms were equal in size. The curved line plots actual distribution of production. The distance between the two lines indicates the relative degree of concentration of ownership. Thus, the graph shows that 60 percent of post and pole producers are responsible for only 20 percent of total volume produced in the State. Ninety percent of producers account for only two-thirds of production, leaving 10 percent (two firms) responsible for more than one-third of total volume. These two firms are as dominant in the post and pole sector as their counterparts, Champion and Plum Creek, in the lumber and plywood sectors of the State.

Although Montana's post and pole production is concentrated, the product market is not confined to the State. Manufacturers in Montana face competitors throughout

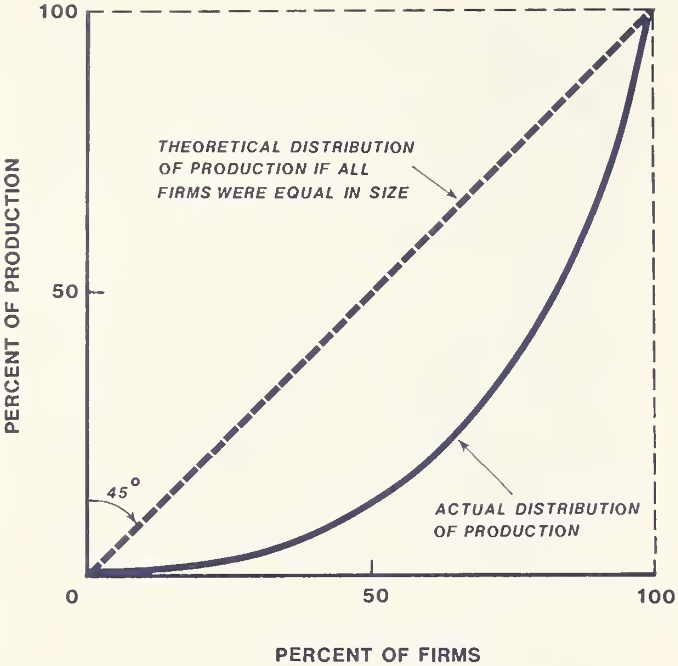

Figure 1—Concentration of manufacturing of posts and poles in Montana.

the West. An unknown quantity of posts and poles are imported into the State. Thus, while production within the State may be concentrated, a competitive market prevails within the larger post and pole sector. Further, there is evidence to suggest that Montana's producers participate in that larger market.

Current Markets and Channels of Distribution

The survey revealed the geographic distribution of markets for Montana's post and pole producers. All except one firm reported sales within the State. As shown in table 3, 43.5 percent of the total volume of products was sold in Montana. The California/Nevada market was the second largest (19.6 percent), followed by Wyoming/Colorado and Dakotas/Nebraska (13.2 percent each).

Firms were also asked to identify customers as end user, wholesale distributor, or retail outlet. As shown in table 4, wholesalers purchased 43.5 percent; end users 34.5 percent; and retail outlets 21.1 percent of total volume produced.

Market demand was assessed by the responses of producers to a list of factors that might affect product sales. Producers were asked to assess the importance of each item. Items were weighted according to importance. Market demand is affected by:

Item	Score[1]
Economic health of agribusiness	35
Geographic location of plant	22
Freight rates	19
Highway and public works	18
Housing construction	13
Advertising	11
Competition with foreign markets	1
Availability of export markets	1

The weighted scores indicate that the economic health of agribusiness is the most important influence on roundwood product sales. The geographic location of the business, freight rates, and highway/public works construction were of about equal importance to producers.

Table 3—Destination of shipments from Montana post and pole producers

Geographic area	Volume	Total production
	Ft³	*Percent*
Montana	1,335,576	43.5
Pacific Northwest	16,339	.5
California/Nevada	602,016	19.6
Wyoming/Colorado	414,384	13.5
Arizona/New Mexico	20,526	.7
Dakotas/Nebraska	405,181	13.2
Midwest	27,612	.9
Oklahoma/Texas	79,248	2.6
Canada	50,538	1.6
Other/unknown	122,367	3.9
Total	3,073,787	100.0

Table 4—Purchasers of roundwood products

Type of purchaser	Volume	Total production
	Ft³	*Percent*
Wholesale	1,335,956	43.5
End user	1,059,782	34.5
Retailer	648,305	21.1
Other/unknown	29,744	.9
Total	3,073,787	100.0

[1]Scores represent summary of responses weighted by (2) for a great deal of importance, (1) for some importance, and (0) for no importance.

Raw Materials

The firms surveyed were asked to indicate the source of raw materials and volumes purchased. Sources included the Forest Service, the State of Montana, private owners, and other public land agencies.

Table 5 shows that the Forest Service and privately owned lands supplied two-thirds of the raw materials. Most firms bought from both private and Forest Service sources, but five firms were solely reliant on one or the other.

Producers were asked if they had problems acquiring raw materials within the last 5 years. Out of 20 firms surveyed, 12 (60 percent) reported some difficulty. Nine of those firms expressing problems obtained 50 percent or more of their raw material from Forest Service lands.

The problem most frequently cited was difficulty in finding people willing to cut and deliver materials at competitive prices. Unavailability of timber and red tape were mentioned by more than half of the manufacturers.

Firm Size and Its Relationship to Marketing Channels and to Source of Raw Materials

Our study examined the relationship of firm size, source of raw materials, and marketing channels. For purposes of this analysis, the post and pole producers were divided into quartiles based on size, with cutoff points determined by production volume.

Data on sales of products are presented in table 6. These data show dramatic differences in geographic markets between the large and small firms. Thus, while 47 percent of the total volume of all sales takes place within Montana, only 25 percent of the volume of large producers is marketed in-State. Small producers sell almost exclusively to Montana purchasers.

Category of purchasers was also related to firm size, using the same quartiles. The results displayed in table 7 suggest that the smaller firms sell to end users to a considerably greater extent than do the five largest producers

Table 5—Source of raw materials

Owner	Volume	Total production
	Ft³	*Percent*
Forest Service	1,087,609	35.4
Private	959,341	31.2
Other public	899,401	29.3
State	127,436	4.1
Total	3,073,787	100.0

Table 6—Geographic markets by firm size

Firm size[2] (quartiles)	Product destination[1]: Inside Montana Volume	Percent Q-sales	Outside Montana Volume	Percent Q-sales
Top	481,823	(25)	1,348,948	(75)
Second	522,864	(69)	233,536	(31)
Third	357,774	(93)	46,707	(7)
Fourth	73,116	(94)	5,062	(6)
Subtotal	1,435,577		1,634,253	
Percent total	(47)		(53)	
Total		3,069,830		

[1]Only known product destinations included.
[2]Based on total cubic foot volume produced as follows: top (>200,000), second (200,000-100,000), third (99,000-45,000), fourth (<45,000).

Table 7—Channels of product distribution by firm size

Firm size (quartiles)	Purchaser[1]: End user Volume	Percent Q-sales	Wholesaler Volume	Percent Q-sales	Retailer Volume	Percent Q-sales
Top	298,951	(16)	1,229,253	(64)	384,729	(20)
Second	468,301	(61)	61,662	(8)	236,897	(31)
Third	241,030	(84)	45,041	(16)	0	(0)
Fourth	51,500	(66)	0	(0)	26,679	(34)
Subtotal	1,059,782		1,335,956		648,305	
Percent total	(35)		(44)		(21)	
Total			3,044,043			

[1]Only known purchasers included in table.

Table 8—Source of raw materials by firm size

Firm size (quartiles)	Forest Service Volume	Forest Service Percent Q-total	Private Volume	Private Percent Q-total	Other public Volume	Other public Percent Q-total
	Ownership category[1]					
Top	229,895	(12)	769,292	(40)	907,156	(48)
Second	601,110	(78)	128,702	(17)	37,048	(5)
Third	207,199	(69)	32,573	(11)	62,074	(21)
Fourth	49,405	(63)	28,774	(37)	0	(0)
Subtotal	1,087,609		959,341		1,006,278	
Percent total	(36)		(31)		(33)	
Total			3,053,228			

[1]Only known sources included in table.

of posts and poles. Two-thirds of the volume of the largest five producers is sold to wholesale distributors. Overall, sales to retail outlets constitute the smallest volume of sales for all groups of producers.

Finally, firm size was compared to sources of raw materials. As shown in table 8, while the Forest Service provides one-third of all raw materials, the five largest producers are far less reliant on this source than are the smaller producers.

Cross-sectional Analysis of Raw Materials and Finished Product Prices

The diverse sizes and prices of finished products made it difficult to summarize such data. Ideally, prices should be tied to a volume measurement of wood, such as cubic feet. But all post and pole yards buy raw materials from cutters based on measurement of small-end diameter of each piece. The same is true for product prices. Manufacturers sell posts, poles, and rails of various lengths and small-end diameters, with no standard system of size classes or prices.

In order to aggregate prices for raw materials and finished products, we developed an equation that incorporates diameter and length. Regression analysis was used to obtain summary coefficients for raw material prices as a function of diameter squared (D^2) times length (L). Equations 1, 2, and 3 represent price estimates for three length classes of raw materials delivered to the yards of the manufacturers.

Thirteen producers complied with our request to furnish current price lists for both raw materials and products. From these lists, 134 raw material prices were obtained. Small-end diameters included on the raw material or "cutters" price lists ranged from 2 to 7.5 inches. Lengths ranged from 5.33 to 30.5 feet.

Equation 1 represents a regression model that predicts the unit price (price per piece) for short lengths of delivered roundwood (5.33 to 10 feet). These lengths are generally associated with fenceposts, tree props, or grape stakes. Equations 2 and 3 are regression models where the coefficients represent price estimates for the medium-length and long-length classes of raw materials.

Segmenting reported prices into three length classes resulted in better explanatory equations than would have been the case with ungrouped data. Specification of independent variables was identical for the three size classes. Each equation uses a curvilinear measure, the exponential of length in feet, which indicates that price per piece increases at a decreasing rate for longer lengths. A "volume" type variable, D^2L, using small-end diameter (D) measured in inches multiplied by length (L) measured in feet, serves as a proxy for cubic volume.

Estimates for product prices were determined using a similar method. The 13 firms that submitted prices for products are again the foundations for the post, pole, and rail price equations.

Equation 1. Price Equation for Short-length Raw Materials—

$$P_1 = 0.1799 + 0.0027\,D^2L + 1.16210e.05\,e^L \qquad (1)$$

$$n = 62$$

Adjusted $R^2 = 0.839$ $\qquad$ $F(2/59) = 159.693$

Standard Error as a percentage of mean Y (unit price) = 19.39 percent

where:

P_1 = price for lengths 5.33 through 10.0 feet

D = diameter in inches

L = length in feet

e = exponential function.

Equation 2. Price Equation for Mid-length Raw Materials—

$$P_2 = 0.3604 + 0.0039\,D^2L + 1.59146e.08\,e^L \qquad (2)$$

$$n = 48$$

Adjusted $R^2 = 0.944$ $\qquad$ $F(2/45) = 398.785$

Standard Error as a percentage of mean Y (unit price) = 14.54 percent

where:

P_2 = price for lengths 10.1 through 18.0 feet.

Equation 3. Price Equation for Long-length Raw Materials—

$$P_3 = 0.7943 + 0.0056\,D^2L + 1.30432e.13\,e^L \qquad (3)$$
$$n = 24$$

Adjusted $R^2 = 0.863$ $\qquad F(2/21) = 79.693$

Standard Error as a percentage of mean Y (unit price) = 79.69 percent

where:

P_3 = price for lengths 18.1 through 30.5 feet.

There were more than 1,000 observed prices indicative of the size, length, treatment, and other processing (peeling, pointing, drilling, doweling). A systematic 10 percent sample of the post, pole, and rail prices, FOB producer's yard, was taken from these price lists and used as data for deriving the regression coefficients.

Equation 4 presents the model for post prices. Due to basic size similarities, other products like grape stakes are included in the data used for this equation. The upper length for posts included was arbitrarily set at 10 feet. The D^2L variable represents the same volume type measure utilized in the raw material price equations.

Equation 4. Price Equation for Post Lengths Under 10 Feet—

$$P_4 = 0.1099 + 0.9643\,H + 0.0128\,D^2L + 0.1165\,SAT \qquad (4)$$
$$n = 41$$

Adjusted $R^2 = 0.834$ $\qquad F(3/37) = 67.741$

Standard Error as a percentage of mean Y (unit price) = 23.31 percent

where:

P_4 = price for lengths under 10 feet

H = drilled, yes = 1; no = 0

D = diameter in inches

L = length in feet

SAT = surface area treated.

Because some posts are fully treated and others are butt-treated, it was assumed that the product price would reflect the surface area treated. A proxy for surface area was estimated using the small-end diameter in inches, the length (L) of the piece in feet actually treated, and the constant, π, so that: $SAT = \pi/12\,DL$.

The other variable in the price equation for posts, drilled (H), is a dummy variable where a value of 1 was assigned if the post had holes drilled in it for doweled rails. The sample included both two- and three-hole posts. Other variables for pointed/unpointed and peeled/unpeeled characteristics were not statistically significant and were eliminated from the final equation.

Equations 5 and 6 represent the models for short and long poles. Short poles ranged from 10.1 through 16 feet in length. Long poles ranged from 16.1 to 30.5 feet. The variables in the two pole equations are defined as in equation 4.

Equation 5. Price Equation for Short Poles—

$$P_5 = 0.5836 + 0.0177\,D^2L + 0.2328\,SAT \qquad (5)$$
$$n = 31$$

Adjusted $R^2 = 0.913$ $\qquad F(2/28) = 146.504$

Standard Error as a percentage of mean Y (unit price) = 24.86 percent

where:

P_5 = price for poles 10.1 through 16.0 feet.

Equation 6. Price Equation for Long Poles—

$$P_6 = -0.0942 + 0.0170\,D^2L + 0.2034\,SAT \qquad (6)$$
$$n = 14$$

Adjusted $R^2 = 0.780$ $\qquad F(2/11) = 24.097$

Standard Error as a percentage of mean Y (unit price) = 23.43 percent

where:

P_6 = price for poles 16.1 through 30.5 feet.

Equation 7 is the estimated price equation for rails. Rails were defined as reported on producers' price lists. They are similar in length to posts and poles (as small as 8 feet in length, but may be as large as 20 feet in length). Some rails are treated and others are not. Some are doweled on the ends, although doweling usually increases the price of a rail by less than $0.50 and was not a significant variable.

Equation 7. Price Equation for Rails—

$$P_7 = -0.0942 + 0.0170\,D^2L + 0.1797\,SAT \qquad (7)$$
$$n = 22$$

Adjusted $R^2 = 0.801$ $\qquad F(2/19) = 43.361$

Standard Error as a percentage of mean Y (unit price) = 37.08 percent

where:

P_7 = price for rails.

The final statistical price model was developed for wooden gates. Manufacturers offered a variety of gates, with optional lengths, number of rails, and peeled or unpeeled rails. Gate lengths ranged from 4 to 16 feet and the number of rails from two to six. Equation 8 is based on 46 price-product observations from six producers.

Equation 8. Price Equation for Gates (Unassembled)—

$$P_8 = -0.1198 + 2.4297\,L + 1.2630\,R - 1.7824\,P - 0.4774\,L{*}P + 2.6043\,R{*}P \qquad (8)$$
$$n = 47$$

Adjusted $R^2 = 0.898$ $\qquad F(5/41) = 81.787$

Standard Error as a percentage of mean Y (unit price) = 9.04 percent

where:

P_8 = price of gates

L = length

R = number of rails

P = peeled, yes = 1; no = 0

$L{*}P$ = length times peeled

$R{*}P$ = number of rails times peeled

Table 9—Value added by manufacturing

Product	Volume	Purchase price		Product price		Value added	
		Per unit	Per cubic foot	Per unit	Per cubic foot	Per unit	Per cubic foot
	Ft³	*Dollars*					
6.5-foot by 4-inch-top fencepost, 3-foot treated, no holes	0.64	0.47	0.73	1.80	2.81	1.33	1.48
12-foot by 3-inch-top rail untreated	.78	1.06	1.36	2.35	3.01	1.29	1.65
15-foot by 6-inch-top pole untreated	3.55	2.52	.71	8.97	2.53	6.45	1.82
15-foot by 6-inch-top pole full treatment	3.55	2.52	.71	14.46	4.07	11.94	3.36

Miscellaneous post and pole products and their average prices, computed directly from price lists supplied by manufacturers, are summarized as follows:

Product	Unit price
Peeled jackleg posts (doweled and drilled)	$ 3.57
Unpeeled jackleg posts (doweled and drilled)	2.39
Haystack panels (16-foot lengths)	15.50
Portable corrals (12 and 16 feet, peeled and unpeeled)	24.75

Value Added by Manufacturing

The equations developed for raw material prices and for the sale price of products, FOB producer's yard, can now be used to estimate value added by manufacturing beyond the cost of raw materials. Table 9 gives examples for selected products, while appendix A demonstrates how the equations were used to obtain the prices.

Using the fencepost as a standard product (6.5-foot length, 4-inch top), the producer pays about $0.47 per post for raw material delivered to the yard, or $0.73 per cubic foot. After peeling, pointing, capping, and treating a 3-foot butt portion, the post is sold for $1.80 at the yard or about $2.81 per cubic foot. Value added in manufacturing for capital, labor, and preservatives is $1.33 per unit, or about $1.48 per cubic foot. The other entries in the table are self explanatory.

The main factor affecting value added per cubic foot is the application of preservatives. Most post and pole manufacturers specify the delivery of green lodgepole logs. This may reduce preservative costs because dry wood absorbs more preservative than green wood. Also, application of a preservative such as pentachlorophenol requires vats of various lengths as well as additional amounts of labor and production time.

ESTIMATING RAW MATERIAL DEMAND

A Primer on Supply and Demand

This section describes the demand for small-diameter logs used to manufacture post and pole products. Because allocation of resources in a market economy centers around the concepts of supply and demand, a brief review of economic principles may be helpful.

In general, demand for a resource is characterized by: (1) an inverse relationship between the price of a resource and the quantity that will be purchased, and (2) shifts in the demand function due to changes in variables such as the price of goods related to the consumption or use of the resource or the purchasing power of consumers. These two aspects of demand are shown in figure 2. Demand curve D1 and movement along this function or schedule demonstrates the inverse relationship between price and quantity. The demand function D2 demonstrates how a demand function can shift from its original (D1) location in response to changes related to the consumption or use of the resource.

The supply of goods in the marketplace is usually thought of as the aggregate of the goods produced and offered for sale. Supply is related to both product price and the costs of factors of production. Notice in figure 3 that the supply (S1) of goods is an increasing function of product price. Shifts in the supply function demonstrated by (S2) reflect changes in unit costs of production inputs such as wage rates or raw material costs.

The price or value of goods in the marketplace is thought of as the simultaneous result of supply and demand forces. Thus, combining the graphs of figures 2 and 3, price P_e will result at equilibrium quantity Q_e when the demand function D1 and the supply function S2 intersect as shown in figure 4.

If demand for a product is to be estimated, a basic question is how responsive is quantity demanded to a small change in price? It would appear that this question can be answered by inspecting the slope of the demand function. But the slope of a demand function can be misleading because it depends on the scaling used in measurements. For example, if one measured the quantity demanded for timber in the United States in terms of billion board feet, and defined the price in dollars per thousand board feet, the slope of the demand curve would be different than the case where the analyst defined the quantity in terms of **million** board feet and the price in dollars per **thousand** board feet.

As a result of measurement enigmas, economists have developed the idea of elasticity to measure responsiveness. The price elasticity of demand is defined as the

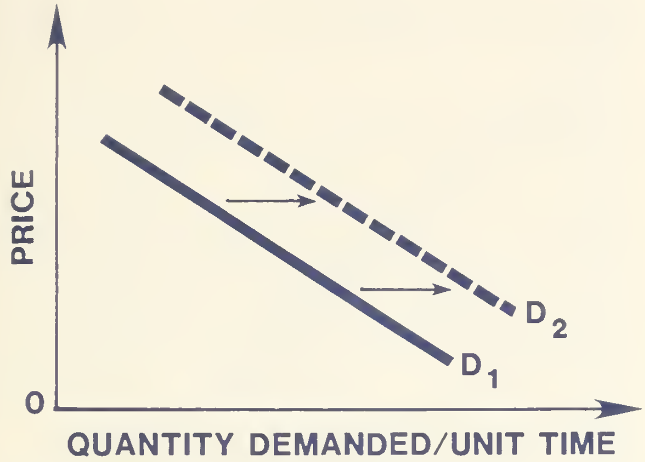

Figure 2—Typical demand function and demand shift.

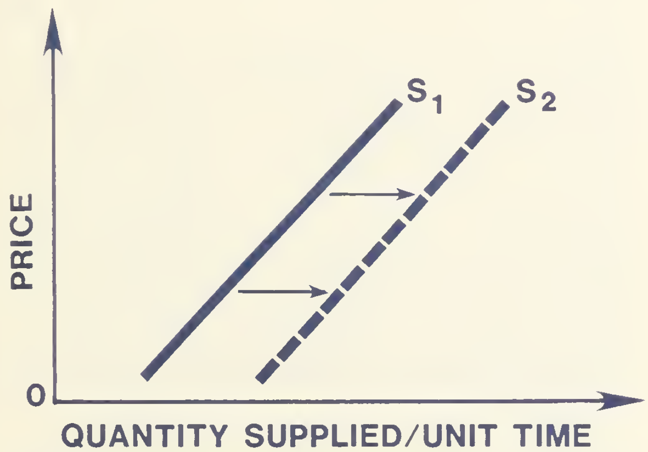

Figure 3—Typical supply function and supply shift.

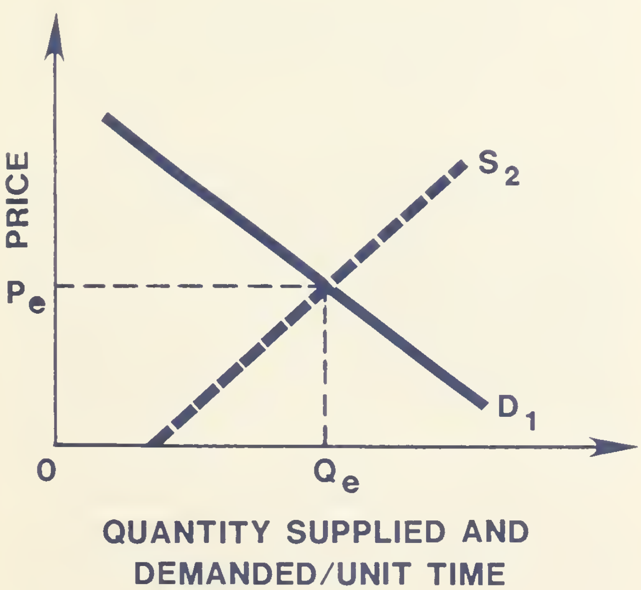

Figure 4—Price determination.

percentage change in quantity demanded which corresponds to a small percentage change in the price of the goods. Unlike the slope of a demand function, elasticity is unitless and scale adjusted.

Just as there is a price elasticity of demand, there is also a price elasticity of supply. In addition, elasticities can also be estimated for the variables that shift the supply and demand functions. Estimates of elasticity tell analysts a good deal about the nature of the market for resources. Recalling that the price elasticity of demand is the percentage change in quantity divided by the percentage change in price, demand is said to be price elastic if the absolute value of the percentage quantity change exceeds the absolute value of the percentage price change. Conversely, demand is price inelastic if the percent quantity change is less than the percentage price change, again in terms of absolute values. The idea of elasticity is applied to any number of economic variables and phenomena, but of importance here is the point that elastic demand is more price responsive than inelastic demand.

Price Elasticity of Demand for Materials

Two alternative approaches were used to estimate the price elasticity of demand for small-diameter logs in the post and pole sector. First, the underlying production relationships that shape the supply function illustrated in figure 3 were studied. Basic to this approach is an understanding of the relationship between capital and labor employed in the manufacturing of post and pole products. Data obtained from producers resulted in the estimation of a production function for the post and pole sector. In turn, this production function allows inferences to be made about the demand for raw materials used in the manufacturing process.

An alternative and somewhat less conventional approach was used to estimate the price elasticity of demand for small-diameter logs. This entailed an analysis of responses to questions about production decisions given changes in raw material prices. As will be shown, the two approaches to demand estimation, while producing somewhat different estimates of elasticity, provide mutually reinforcing information.

Production and Implied Demand for Logs

The production function approach to demand estimation for logs involves three steps. First, a production function that estimates the numerical relationships between inputs utilized and the level of output produced is estimated. Second, the results of this production function are used to make inferences about the total cost and marginal cost functions. Finally, from the marginal cost function, conclusions are drawn about the price elasticity of the derived demand for small logs.

In equation form a production function might be commonly stated as follows:

$Q = f(K, L, N)$

where:

Q = quantity of posts and poles produced

K = amount of capital

L = amount of labor

N = amount of raw materials.

The methodological problem apparent with post and pole manufacturing is the overwhelming relationship between Q, the physical measure of output, and N, the measure of raw material input. As a result of the overwhelming relationship between Q and N, an alternative specification of the production function, where N is left out, is presented. The revised function is as follows:

$Q = f(K, L)$

As in all production studies, the measurement of capital, K, can be elusive (Walters 1963). The questionnaire evoked responses for the technical production capacity of each product per 8-hour shift. These capacity figures were converted to annual capacities by assuming 50 producing weeks per year. Then a ratio of actual annual production to capacity was multiplied by the reported capital stock value and was used to measure capital utilization. Labor was measured by the average annual number of employees reported by producers. Natural logarithins of all the variables were taken to linearize the model so that simple linear regression analysis would be used to estimate model coefficients.

Equation 9. Production Function—

$$\ln Q = 10.13 + 1.09 \ln K + 0.01 \ln L \qquad (9)$$

$n = 19$

Adjusted $R^2 = 0.768$ $F(2/16) = 27.023$

Standard Error as a percentage of mean Y (total ln cubic feet) = 5.89 percent

Taking antilogs of the above model, it can be reexpressed as:

Equation 10. Production Function—

$$Q = 10.13 K^{1.09} L^{0.01} \qquad (10)$$

The sum of the exponents in equation 10 has an important economic meaning. Where their sum is greater than 1, increasing returns to scale between inputs and outputs are inferred (Silberberg 1978). The idea of increasing returns is not consistent with a stable industry equilibrium and cannot lead to meaningful logical propositions. In addition, labor, as specified, is not a significant variable and is correlated with capital ($R = 0.51$).

An alternative production function, using the original Cobb-Douglas model where the exponents are restricted to a sum of 1, was estimated for the data. This restricted model is consistent with constant scale economies. The Cobb-Douglas function is presented as equation 11.

Equation 11. Cobb-Douglas Production Function—

$$\ln Q = 10.17 + 0.979 \ln (L/K) \qquad (11)$$

$n = 19$

Adjusted $R^2 = 0.940$ $F(1/17) = 249.910$

Standard Error as a percentage of mean Y(ln cubic feet produced/K) = 35.66 percent

The restricted model appears to fit the data better than the first model. The potential multicollinearity between K and L is eliminated and the overall F level improves substantially. A statistical test was conducted to determine whether differences in the two models were significant (Koutsoyiannis 1977). It was found that the hypothesis of no difference could not be rejected so the restricted production function model was chosen.

By rearranging variables and taking antilogarithms, the statistically estimated post and pole production function is:

Equation 12. Post and Pole Production Function—

$$Q = 10.17 K^{0.979} L^{0.021} \qquad (12)$$

To summarize, there is both a fixed quantitative relationship between the use of small-diameter logs and the production level and constant returns to scale over the observable levels of production. It is now possible to focus the analysis on production costs.

It is well known in economics that constant returns to scale produce a linear total cost function (TC) such as depicted in figure 5a. That is, the total cost of manufacturing post and pole products rises at a constant rate holding the unit costs of capital, labor, and raw materials constant. The rate of change of the total cost function, or more specifically, the change in total costs with respect to a change in the level of production is termed marginal cost (MC).

Because the total cost (TC) rises at a constant rate, marginal cost (MC) will be a constant (horizontal line), as is shown in figure 5b. Under conditions where the unit prices of capital, labor, and logs are constant and the number of producers and the technological state of the arts are unchanged, the MC function is synonymous with the aggregate supply function. Thus, the horizontal supply function is perfectly elastic with respect to product price.

Determining the price elasticity of demand for factors produced in fixed proportions with the level of output dates back to Marshall (Friedman 1976). The principles are demonstrated graphically in figures 6a and 6b. In figure 6a, post and pole price is held constant at a level of A, and the marginal cost of producing these products less raw materials costs ($MC_{K,L}$) is shown at level B. The derived demand for raw materials is the product demand less the marginal costs of production excluding log costs of A minus B. Given that demand and $MC_{K,L}$ are both horizontal functions, the derived demand for logs will also be horizontal, as indicated in figure 6b.

The conclusion drawn from the production function approach is that the price elasticity of demand for small-diameter logs used in the manufacturing of post and pole products is perfectly elastic or price responsive.

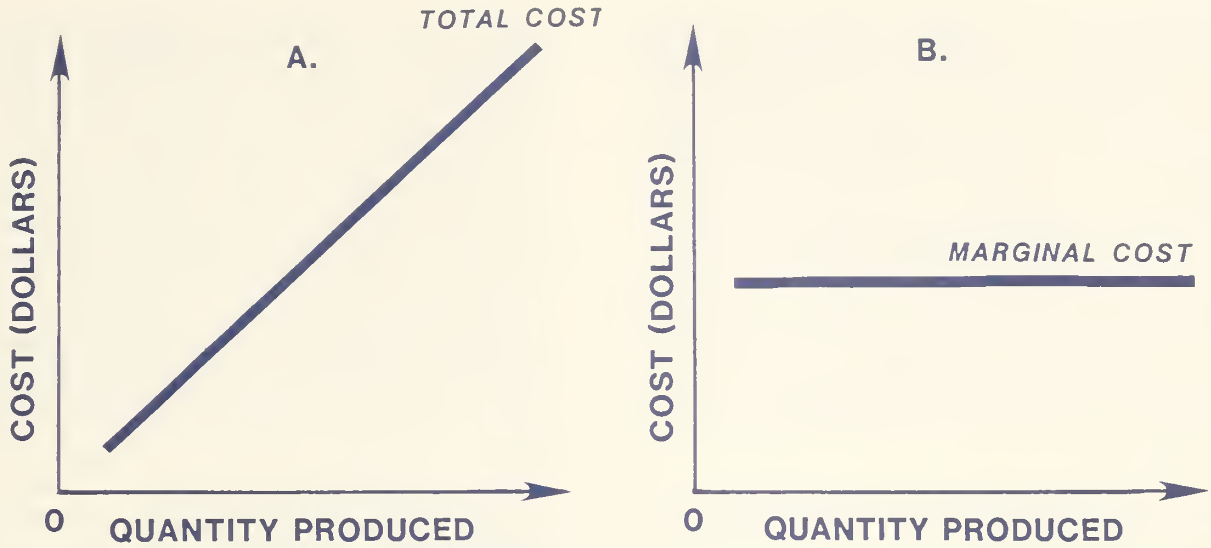

Figure 5—(a) Total cost function, (b) marginal cost function.

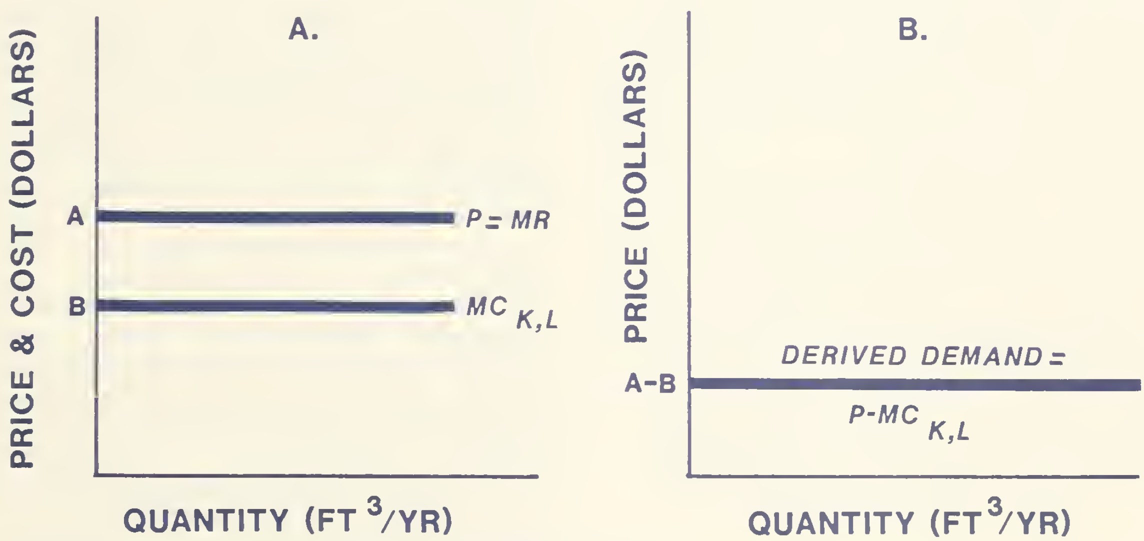

Figure 6—Product demand, marginal costs of production, and short-run derived demand for raw materials where the quantitative relationship between raw material input and product output is fixed.

Raw Material Demand Based on Willingness to Pay

A second approach to estimating the price elasticity of demand for raw materials involved use of data from the survey. During the interviews, each respondent was asked how production would change if there was a 10 percent increase in raw material prices. Given the fixed relationship between raw material inputs and production outputs, the results of this question were used to develop an alternative estimate of the derived demand for raw materials.

Responses were given by product and were aggregated for the firms included in the study. Overall, the response to a 10 percent increase in raw material prices (assuming product prices and employee wages did not change) was a 15.19 percent decrease in output. It is inferred that there would be an equal decrease in the purchase of raw materials. Thus, using the willingness-to-pay approach, the predicted price elasticity of demand for raw materials is –1.52.

Conclusions Regarding Raw Material Demand

The estimate of price elasticity based on the production function approach and the estimate based on producer willingness to pay both suggest that demand is price elastic. The question may arise as to why the measures of elasticity have such a broad range. It appears that during

the year the post and pole sector was studied, firms were operating far below their productive capacity. An estimate of capital utilization based on questions about the firm's 8-hour capacity indicated an exceptionally low utilization of capital. Important product markets in agribusiness and public highway construction were very depressed during this period.

It may be that the finding of constant returns to scale was the result of low levels of production rather than the technical relationships between inputs and outputs observable during normal levels of production. Likewise, the conclusion that constant marginal costs yield perfect price elasticity of demand for raw materials may not be the case. A time series of the post and pole sector would help clarify the price elasticity of demand for small-diameter wood products.

MARKET SUPPLY OF POST AND POLE PRODUCTS

The production function and the associated marginal cost curve for the representative post and pole firm shown in figure 5b lead to some logical inferences about the aggregate short-run supply function. The perfectly elastic MC function for the competitive firm suggests a perfectly elastic short-run supply function. Of course, the short-run supply function assumes the number of firms, factor prices, and technology to be constant.

As was the case in estimating raw material demand, producer responses were used to develop an alternate measure of supply. Producers indicated how much they would change production if there were a 10 percent increase in product prices, given production costs did not change. The aggregate response was an increase in volume of 646,823 ft^3, or a 19.72 percent change. This translates to an estimate of price elasticity of supply of 1.97 since elasticity is simply the percentage change in quantity demanded divided by the percentage change in price. Thus, both approaches yield consistent results that indicate the supply of post and pole products is price elastic.

CONCLUSIONS

The results of this study suggest a variety of means for increasing the utilization of small-diameter lodgepole pine.

First, judging by the production function estimated by this study, constant returns to scale do not seem to limit firm size. Rather, the individual firm and the post and pole sector as a whole are limited by the size or extent of the market for their products. The largest firms ship more of their products out of State, both in absolute and in relative terms, than do the smaller firms. Further, the out-of-State markets are characterized by different distribution channels than the in-State market. The top quartile of producers primarily sells to wholesalers rather than end users, as is the case with smaller firms. It is also of note that about 1 out of every 5 ft^3 of post and pole products manufactured in the State is shipped to the California/Nevada area.

Second, the most significant external influence on demand is the economic health of agribusiness. The short-term prospects for many components of agriculture are affected by changes in the value of the U.S. dollar relative to foreign currencies and to the structure of production costs of American goods relative to those of other nations. The long-term outlook for American agriculture is likely to be brighter if densely populated countries (particularly in the Pacific Rim) acquire more wealth and increase their demand for agricultural products.

The problems of freight rates and location will continue to plague Montana producers. This will be particularly true of lower priced products. A rise in freight costs per cubic foot increases the price of low cost products at destination relative to the delivered price of higher priced products. Thus, firms with wood preservative facilities may be better candidates for expansion than those without that capability. Treated products command higher prices than untreated products.

Third, the results of this study indicate that the National Forests are not the primary source of raw materials for posts and poles. Even though 60 percent of Montana's total forest lands available for timber harvesting are in Forest Service ownership, post and pole producers secured only 35 percent of their raw materials from this source. The largest producers are the least reliant on the National Forests, which suggests that their suppliers operate in a different arena than those who sell to smaller firms.

Fourth, the analysis of raw material demand and product supply suggests that purchases and production levels are both quite sensitive to price. Demand for raw materials is price elastic, as is product supply.

A wide variety of raw material prices and products prices were observed within the post and pole sector. The main reason for this variation in prices is the myriad sizes of products available. By means of regression analysis, price equations were estimated for the sector as a whole. These equations suggest that the value of the raw materials and products is highly uniform, given allowances for size variation and/or other product characteristics such as treatment with preservative. This uniformity in price indicates that Montana is a component of some larger market area. Because market areas can be distinguished as regions with uniform price, it appears that submarkets do not exist within the State. The raw material and product price equations provide good estimations because of the geographic uniformity of value.

In summary, new information has been provided about post and pole manufacturing in Montana. The nature of the firms, mix of products, competitiveness of markets, channels of distribution, structure of costs, and prices of raw materials and products have been described in detail. This sector is often overlooked because it operates at the periphery of the larger lumber and plywood industry. Nevertheless, it represents an important and efficient utilization of small-diameter timber for the production of wood products.

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APPENDIX A: DEMONSTRATION OF THE USE OF RAW MATERIAL AND PRODUCT PRICE EQUATIONS

Problem: Estimate cost and price for an 8-foot-long post with 6-inch small-end diameter (top) converted into a fully treated decorative fencepost with holes.

Raw Material Cost Equation—

$$P_1 = 0.1799 + 0.0027\,D^2L + 0.00001162\,e^L$$

where:

P_1 = cutters' price per piece delivered to yard
D = diameter in inches
L = length in feet
e^L = the exponential function 2.718282.

$$P = 0.1799 + 0.0027(36)(8) + 0.00001162(2.718282)(8) = \$0.99 \text{ per post}$$

Finished Product Price Equation—

$$P_4 = 0.1009 + 0.9643\,H + 0.0128\,D^2L + 0.1165\,SAT$$

where:

P_4 = cutters' price per piece delivered to yard
D = diameter in inches
L = length in feet
H = a "dummy" variable set to a value of 1 when holes are drilled or set to 0 when holes not drilled
SAT = estimate of surface area treated $(\pi)(D/12)(L)$.

$$P_4 = 0.1009 + 0.9643(1) + 0.0128(36)(8) + 0.1165\,(\pi)(6/12)(8) = \$6.21$$

APPENDIX B: EQUIPMENT SUMMARY

The 21 firms used in the study indicated that they used the following equipment in their businesses:

Equipment	Number of firms
Pointer	20
Pole shaver (peeler)	19
Butt vats	17
Full-length vats	14
Cutoff saws	13
Mortising drill	11
Doweler	9
Pressure cylinder	4
Forklifts	4
Boilers	3
Kilns	2
Loaders	2

Jackson, David H.; Jackson, Kathleen O. 1989. Montana's post and pole industry: an economic analysis of production and markets. Res. Pap. INT-398. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 14 p.

Montana's post and pole manufacturing industry is described in terms of the products manufactured, size of firms, degree of competition, markets, raw material costs, and product prices. Estimates are presented for demand for raw material and the supply of finished products.

KEYWORDS: roundwood products, timber utilization, forest economics, forest industries, small tree utilization

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